Fishery Data Series No. 02-20

Abundance of the Chinook Salmon Escapement on the Alsek River, 2001

by

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and

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October 2002

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

Centimeter	cm
Deciliter	dL
Gram	g
Hectare	ha
Kilogram	kg
Kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	var

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ABSTRACT

Abundance of chinook salmon *Oncorhynchus tshawytscha* returning to spawn in the Alsek River in 2001 was estimated with a mark-recapture experiment conducted by the Alaska Department of Fish and Game, the Canada Department of Fisheries and Oceans, and the Champaign/Aishihik First Nation. Age, sex, and length compositions for the immigration were also estimated. Set gillnets fished near the mouth of the Alsek River during May, June, and July, 2001 were used to capture 589 large (≥660 mm MEF) immigrant chinook salmon, of which, 529 were marked with individually numbered spaghetti tags, a hole punched in their left opercle, and removal of an axillary appendage. In addition, 73 medium (440-659 mm) fish were marked. During July and August, chinook salmon were captured at spawning sites and inspected for marks. We used a modified Petersen model to estimate that 11,246 (SE = 1,336) large chinook salmon immigrated into the Alsek River above Dry Bay. Canadian fisheries on the Tatshenshini River harvested an estimated 224 large chinook salmon, leaving an escapement of 11,022 large fish. We used a second Petersen model to estimate that 12,885 (SE 1,438) chinook salmon ≥440 mm MEF immigrated into the Alsek River above Dry Bay. About 14% of the total estimated spawning escapement in the Alsek River (1,825 chinook salmon) were counted at the Klukshu River weir.

An estimated 9.8 % of the Alsek River escapement were age -1.2, 68.9% age -1.3, and 20.5% age -1.4, with 314 males and 322 females sampled.

Key words: chinook salmon, *Oncorhynchus tshawytscha*, Alsek River, Klukshu River, Tatshenshini River, mark-recapture, escapement, abundance

INTRODUCTION

The Alsek River originates in the Yukon Territory, Canada, and flows in a southerly direction into the Gulf of Alaska, southeast of Yakutat, Alaska (Figure 1). Chinook salmon *Oncorhynchus tshawytscha* returning to this river are caught primarily in commercial and subsistence set gillnet fisheries in the lower Alsek River and in recreational and aboriginal fisheries on the upper Tatshenshini River in Canada (Tables 1, 2). Small harvests of this stock are also probably taken in marine recreational and commercial set gillnet and troll fisheries near Yakutat. Exploitation of this population is managed jointly by the U.S. and Canada through a subcommittee of the Pacific Salmon Commission (PSC) as part of the U.S./Canada Pacific Salmon Treaty (PST) adopted in 1985 (TTC 1999).

Counts of chinook salmon spawning in tributaries of the Alsek River have been collected since 1962 (Table 3). Since 1976, the Canadian Department of Fisheries and Oceans (DFO) has operated a weir at the mouth of the Klukshu River to count chinook, sockeye *O. nerka*, and coho salmon *O. kisutch*. The weir count is used as the index for the Alsek River. Mark-recapture studies in 1997–2000 indicate that Klukshu River chinook salmon account for between 15 and 20% of the total run (Pahlke et al 1999; Pahlke and Etherton 2001a, 2001b). Prior to 1997, the proportion of the total chinook salmon escapement to the Alsek River drainage counted at the Klukshu River weir was unknown. The U.S. used a weir expansion of 1.56 (64%) to estimate total Alsek River chinook escapement, while Canada used an expansion of 2.5 (40%) (Pahlke 1997). A recent analysis of the biological escapement goal for Klukshu River chinook salmon used a range of 30% to 100%. A biological escapement goal (BEG) range of 1,100 to 2,300 chinook salmon spawners in the Klukshu River was recommended (McPherson et al. 1998). In 1991, the Transboundary River Technical Committee of the PSC recommended that an expansion factor not be adopted due to the lack of applicable studies (TTC 1991). Annual spawning escapements of chinook salmon in the Klukshu River system have been estimated annually by subtracting from the weir count: (1) harvests taken upstream of the weir site in an aboriginal fishery and; (2) in a sport fishery (1976–1978 only); and (3) brood stock removed at the weir site.

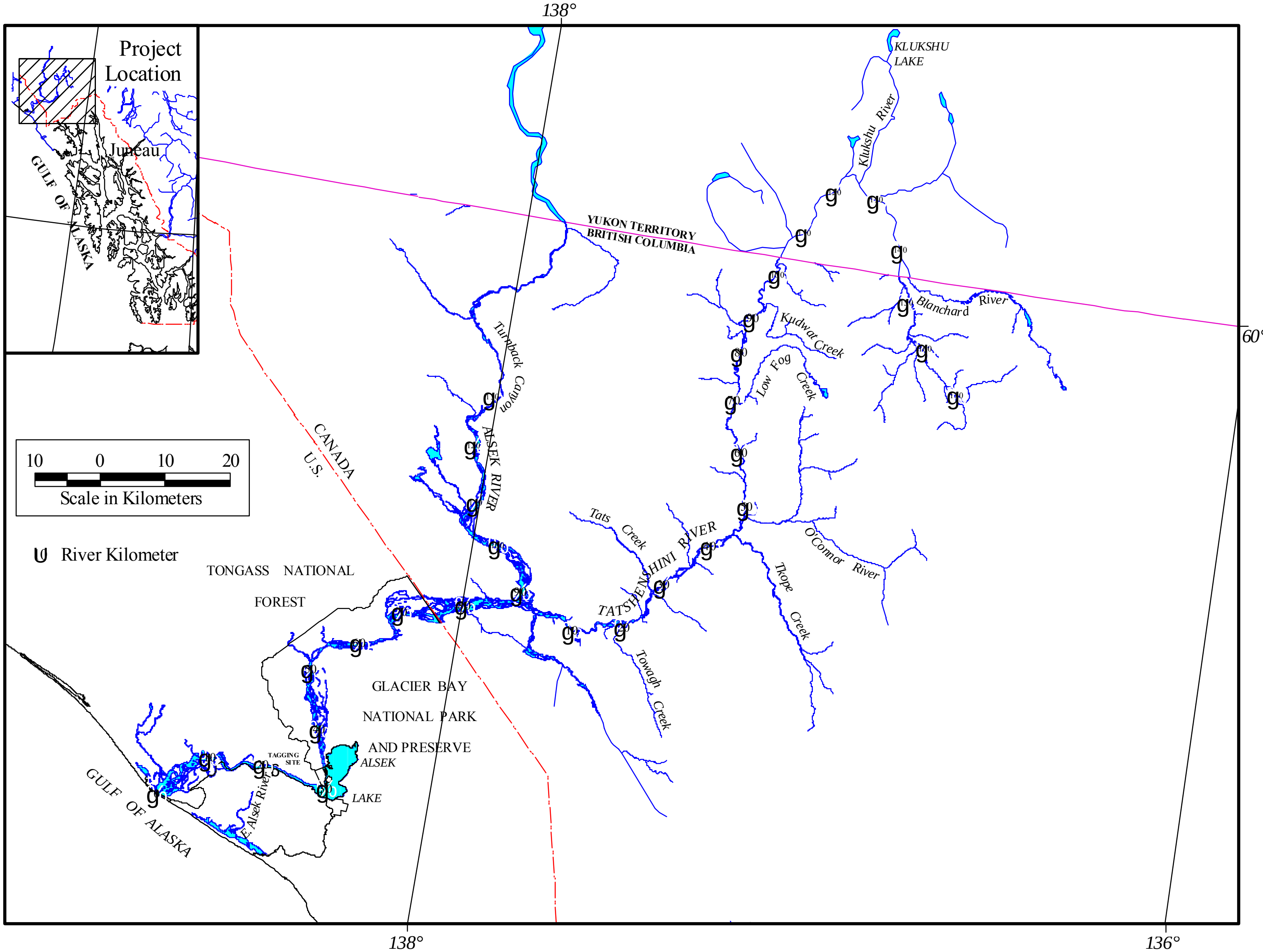

Figure 1.–Alsek River drainage, showing principal tributaries and river kilometers.

Table 1.–Estimated harvests of chinook salmon in Canadian Alsek River fisheries, 1976–2001.

	Klukshu River aboriginal fishery			Canadian sport fishery			
Year	Below weir	Above weir	Total	Dalton Post	Blanchard River	Takhanne River	Total
1976	0	150	150	130	45	25	200
1977	0	350	350	195	67	38	300
1978	0	350	350	195	67	38	300
1979	0	1,300	1,300	422	146	82	650
1980	0	150	150	130	45	25	200
1981	0	150	150	150	200	50	400
1982	0	400	400	183	110	40	333
1983	0	300	300	202	60	50	312
1984	0	100	100	275	125	50	450
1985	0	175	175	170	20	20	210
1986	0	102	102	125	20	20	165
1987	0	125	125	326	113	63	502
1988	0	43	43	249	87	48	384
1989	0	234	234	215	75	41	331
1990	0	202	202	468	162	91	721
1991	268	241	509	384	29	17	430
1992	60	88	148	79	6	18	103
1993	88	64	152	170	25	42	237
1994	190	99	289	197	69	38	304
1995	320	260	580	601	330	113	1,044
1996	233	215	448	423	78	149	650
1997	72	160	232	195	69	34	298
1998	154	17	171	112	43	20	175
1999	211[a]	27	238	122	38	14	174
2000	21[b]	44	65	24	46	2	72
2001	25	87	112	83	18	11	112

[a] Includes 8 fish harvested from Village Creek.

[b] Includes 4 fish harvested from Village Creek and 3 from Blanchard River.

The Alaska Department of Fish and Game (ADF&G) has counted spawning chinook salmon from helicopters since 1981 and earlier from fixed-wing aircraft. Escapement to the Klukshu River is difficult to count by aerial, boat or foot surveys because of deep pools and overhanging vegetation. However, surveys of the Klukshu River are conducted periodically to provide some continuity in the database in the event that funding for the weir is discontinued. The Blanchard and Takhanne rivers and Goat Creek, three smaller tributaries of the Tatshenshini River, are also surveyed annually, but counts from these surveys are not used to index escapements.

Only large (typically age-.3, -.4, and -.5) chinook salmon ≥660 mm mideye-to-fork length (MEF) are counted during aerial or foot surveys. No attempt is made to accurately count small (typically age-.1 ≤439 mm MEF) or medium (440–659 mm and age-.2) chinook salmon. These chinook salmon, also called jacks, are primarily males that are considered to be surplus to spawning needs (Mecum 1990). They are easy to separate visually from their older, larger counterparts under most conditions, because of their shorter, compact bodies and lighter color. They are, however, difficult to distinguish from other smaller species such as sockeye salmon.

In 1997, ADF&G, in cooperation with DFO, instituted a project to determine the feasibility of a mark-recapture experiment to estimate abundance of chinook salmon spawning in the Alsek River drainage (Appendix B). The results of the feasibility project were encouraging, and in 1998 a revised, expanded mark-recapture study was conducted along with a radiotelemetry study to estimate spawning distribution (Pahlke et al. 1999).

Table 2.–Annual harvests of chinook salmon in the U.S. Alsek River commercial and subsistence/personal use gillnet fisheries, 1941–2001.

Year(s)	Commercial harvest	Year(s)	Commercial harvest	Subsistence/ personal use
1941	3,943	1971	1,222	
1942	0	1972	1,827	
1943	0	1973	1,757	
1944	2,173	1974	1,162	
1945	6,226	1975	1,379	
1941–1945 Average	2,468	1971–1975 Average	1,469	
1946	1,161	1976	512	
1947	266	1977	1,402	
1948	853	1978	2,441	
1949	72	1979	2,525	
1950	unknown	1980	1,382	
1946–1949 Average	588	1976–1980 Average	1,652	
1951	151	1981	779	
1952	2,020	1982	532	
1953	1,383	1983	93	
1954	1,833	1984	46	
1955	2,883	1985	213	
1951–1955 Average	1,654	1981–1985 Average	333	
1956	3,253	1986	481	22
1957	1,800	1987	347	27
1958	888	1988	223	13
1959	969	1989	228	20
1960	525	1990	78	85
1956–1960 Average	1,487	1986–1990 Average	271	38
1961	2,120	1991	103	38
1962	2,278	1992	301	15
1963	131	1993	300	38
1964	591	1994	805	60
1965	719	1995	670	51
1961–1965 Average	1,168	1991–1995 Average	436	34
1966	934	1996	771	60
1967	225	1997	568	38
1968	215	1998	550	63
1969	685	1999	482	44
1970	1,128	2000	677	45
1966–1970 Average	637	1996–2000 Average	609	50
		2001	541	19

Since 1999 the project has continued without the radiotelemetry study. The 2001 study had two objectives: (1) to estimate the abundance of large (≥660 mm MEF) spawning chinook in the Alsek River; and (2) to estimate the age, sex, and length compositions of chinook salmon spawning in the Alsek River.

Results from the study provide a survey expansion factor; i.e., an estimate of the fraction of escapement to the Alsek River counted at the Klukshu River weir. Results also provide information on the run timing through the lower Alsek River of chinook salmon bound for the various spawning areas.

Table 3.–Escapement of chinook salmon to the Klukshu River and counts of spawning adults in other tributaries of the Alsek River, 1962–2001.

	Klukshu River												
Year[a]	Aerial count		Weir count	Above-weir harvest AF	Sport	Brood	Escape-ment [b]	Blanchard River		Takhanne River		Goat Creek	
1962	86	(A)	–	–	–		86	–		–		–	
1963	–		–	–	–		–	–		–		–	
1964	20	(A)	–	–	–		20	–		–		–	
1965	100		–	–	–		100	100		250		–	
1966	1,000		–	–	–		1,000	100		200		–	
1967	1,500		–	–	–		1,500	200		275		–	
1968	1,700		–	–	–		1,700	425		225		–	
1969	700		–	–	–		700	250		250		–	
1970	500		–	–	–		500	100	(F)	100		–	
1971	300	(A)	–	–	–		300	–		205	(F)	–	
1972	1,100		–	–	–		1,100	12	(A)	250		38	(F)
1973	–		–	–	–		–	–		49	(A)	–	
1974	62		–	–	–		62	52	(A)	132	(F)	–	
1975	58		–	–	–		58	81	(A)	177	(A)	–	
1976	–		1,278	150	64		1,064	–		38	(F)	16	(F)
1977	–		3,144	350	96		2,698	–		38	(F)	–	
1978	–		2,976	350	96		2,530	–		50	(F)	–	
1979	–		4,404	1,300	0		3,104	–		–		–	
1980	–		2,673	150	0		2,487	–		–		–	
1981	–		2,113	150	0		1,963	35	(H)	11	(H)	–	
1982	633	N(H)	2,369	400	0		1,969	59	(H)	241	(H)	13	(H)
1983	917	N(H)	2,537	300	0		2,237	108	(H)	185	(H)	–	
1984	–		1,672	100	0		1,572	304	(H)	158	(H)	28	(H)
1985	–		1,458	175	0		1,283	232	(H)	184	(H)	–	
1986	738	P(H)	2,709	102	0		2,607	556	(H)	358	(H)	142	(H)
1987	933	E(H)	2,616	125	0		2,491	624	(H)	395	(H)	85	(H)
1988	–		2,037	43	0		1,994	437	E(H)	169	E(H)	54	E(H)
1989	893	E(H)	2,456	234	0	20	2,202	–		158	E(H)	34	E(H)
1990	1,381	E(H)	1,915	202	0	15	1,698	–		325	E(H)	32	E(H)
1991	–		2,489	241	0	25	2,223	121	N(H)	86	E(H)	63	E(H)
1992	261	P(H)	1,367	88	0	36	1,243	86	P(H)	77	N(H)	16	N(H)
1993	1,058	N(H)	3,303	64	0	18	3,221	326	N(H)	351	E(H)	50	N(H)
1994	1,558	N(H)	3,727	99	0	8	3,620	349	N(H)	342	E(H)	67	N(H)
1995	1,053	E(H)	5,678	260	0	21	5,397	338	P(H)	260	P(H)	–	
1996	788	N(H)	3,599	215	0	2	3,382	132	N(H)	230	N(H)	12	N(H
1997	718	P(H)	2,989	160	0	0	2,829	109	P(H)	190	P(H)	–	
1998	–		1,364	17	0	0	1,347	71	P(H)	136	N(H)	39	N(H)
1999	500	P(H)	2,193	27	0	0	2,166	371	E(H)	194	N(H)	51	N(H)
2000	–		1,365	44	0	0	1,321	168	N(H)	152	N(H)	33	N(H)
1991–2000 average	848		2,807	122	0	11	2,675	207		202		41	
2001	–		1,825	87	0	0	1,738	543	N(H)	287	N(H)	21	N(H)

— = no survey; (A) = aerial survey from fixed wing aircraft; (H) = helicopter survey; E = excellent survey conditions; N = normal conditions; P = poor conditions.

[a] Escapement counts prior to 1975 may not be comparable because of differences in survey dates and counting methods.

[b] Klukshu River escapement = weir count minus above-weir aboriginal and sport fishery, and broodstock.

STUDY AREA

The Alsek River drainage covers about 28,000 km^2 (Bigelow et al. 1995). The drainage supports spawning populations of anadromous Pacific salmon, including chinook salmon; however, most anadromous production in the Alsek drainage is limited to the Tatshenshini River because of a velocity barrier on the lower Alsek near Lowell Glacier (Turnback Canyon, rkm 130)(Figure 1). Significant numbers of chinook salmon spawn in various tributary streams of the Tatshenshini River, including the Klukshu River, the Blanchard River, the Takhanne River, and Goat Creek (Figure 2). Other significant spawning areas probably exist downstream of the confluence of the Klukshu and Tatshenshini rivers such as in mainstream areas of the Tatshenshini and Alsek rivers. Small numbers of chinook have been documented spawning in Village, Kane, Silver, Bridge, Detour, O'Connor, Low Fog and Stanley creeks, and in the Bridge River. The Klukshu and upper Tatshenshini rivers are accessible by road from the Haines Highway.

METHODS

The number of large chinook salmon in the Alsek River escapement was estimated from a two-event mark-recapture experiment for a closed population (Seber 1982:59–61). Fish captured by set gillnets in the lower river near Dry Bay and marked were included in event 1. Chinook salmon captured upstream on or near their spawning grounds constituted event 2 in the mark-recapture experiment.

DRY BAY TAGGING

Set gillnets 120 feet (36.5 m) long, 18 feet (5.5 m) deep, and made of 7¼-inch (18.5-cm; chinook gear) stretch mesh, were fished on the lower Alsek River, between May 13 and July 4. From May 16 through July 4, a similar net with sockeye gear (5¼-inch, 13.5cm) was fished at a nearby site. From July 4 on only sockeye gear was fished. Both nets were fished daily, unless high water prevented fishing. The primary fishing site for the chinook gear was at approximately river kilometer (rkm) 19, just above the boundary of the Dry Bay commercial fishery. The tagging site is below all known spawning areas, and is upstream of any tidal influence. Other nearby sites were fished when water levels were too high to safely fish the primary site. The primary site for the sockeye gear was upriver a few km near the outlet of Alsek Lake. Nets were watched continuously, and captured fish were removed from the net as soon as observed. Sampling effort was held reasonably constant across the temporal span of the migration. If fishing time was lost due to entanglements, snags, cleaning the net, etc., the lost time (processing time) was added on to the end of the day to bring fishing time to 8 hours per day per net.

Captured chinook salmon were placed in a plastic fish tote filled with water, quickly untangled or cut from the net, tagged, scale sampled, and their length and sex recorded during a visual examination (as per Johnson et al. 1993). Fish were classified as "large" if their mideye to fork length (MEF) was ≥660 mm, "medium" if between 440 and 659 mm or "small" if <440 mm (Pahlke and Bernard 1996). General health and appearance of the fish were noted, including injuries from handling or predators. Each uninjured fish was marked with a uniquely numbered, blue spaghetti tag, consisting of a 2" (~5-cm) section of Floy tubing shrunk onto a 15" (~38-cm) piece of 80-lb (~36.3-kg) monofilament fishing line. The monofilament was sewn through the musculature of the fish approximately 20 mm posterior and ventral to the dorsal fin and secured by crimping both ends in a line crimp. Each fish was also marked with a ¼-inch-diameter (6-mm) hole in the upper (dorsal) portion of the left operculum applied with a paper punch, and by amputation of the left axillary appendage (as per McPherson et al. 1996). Fish that were seriously injured were sampled to determine length, age and sex but were not tagged.

SPAWNING GROUND SAMPLING

During event 2, pre- and post spawning fish were sampled at the Klukshu River weir. As fish entered a trap in the weir, a portion were captured; sampled to determine their length, sex, and age; inspected for marks; marked with a hole punched in the left operculum to prevent resampling; and released. A trap load of fish were sampled whenever a tagged fish was recognized as being in

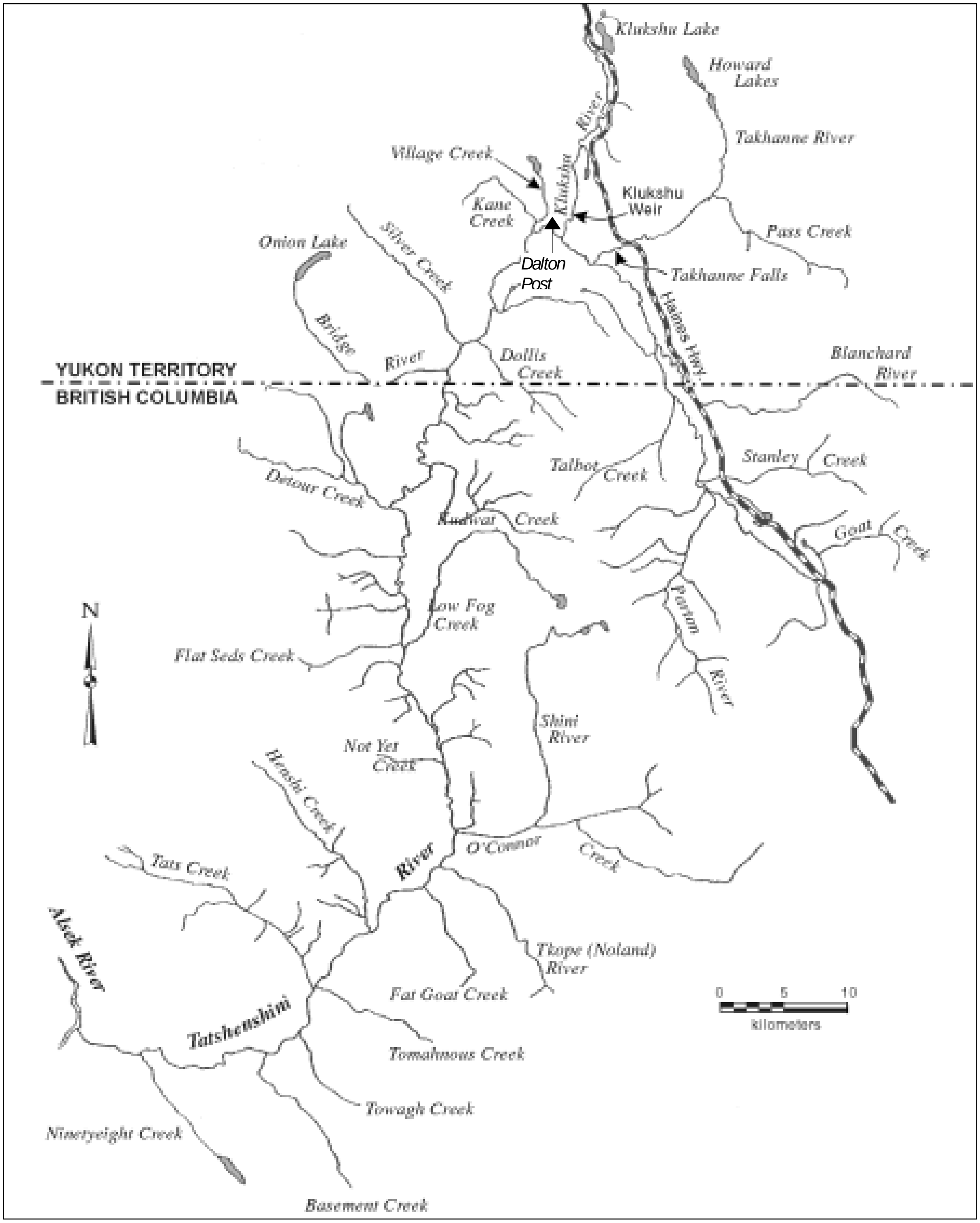

Figure 2.–Tatshenshini River drainage and associated tributaries, Yukon Territory and northern British Columbia.

the trap. Some fish in trap loads with no members recognized as tagged were passed and counted through the weir without being individually handled. In addition, some post-spawning fish and carcasses were sampled upstream of the weir. Foot surveys of the spawning areas on the Blanchard and Takhanne rivers and Goat and Low Fog creeks, were conducted August 2–10, 2001. Carcasses and moribund chinook salmon were sampled to determine length, sex, age and the presence of marks.

FISHERY SAMPLING

Catches in Canadian fisheries in the upper Tatshenshini River and the U.S. gillnet fisheries below the tagging site, were sampled for data on age, sex, and length and were inspected for tags.

ABUNDANCE

The number of marked fish on the spawning grounds was estimated by subtracting the estimated number of marked fish removed by fishing in U.S. fisheries (censored from the experiment) from the number of fish tagged in event 1. Handling and tagging has caused a downstream movement and/or a delay in upstream migration of marked chinook salmon in other studies (Pahlke and Etherton 1999, Bernard et al. 1999, Bendock and Alexandersdottir 1992, Johnson et al. 1992, Milligan et al. 1984). This behavior puts fish marked in June and July at risk of capture in the downstream commercial fishery in U.S. waters that begins in mid-June; fish marked earlier would have no such risk. Censoring marked chinook salmon killed in this fishery avoided bias in estimates of abundance from this phenomenon. The tagging program was well publicized with a reward for each tag recovered, and almost the entire catch goes through one processor where a high proportion of the U. S. catch was inspected for marks.

Because of a reward (Can$2 for spaghetti tag) for each tag returned from the inriver Canadian recreational and aboriginal fisheries, tags from all marked fish caught in these fisheries were considered recovered.

The validity of the mark-recapture experiment rests on several assumptions, including: (a) every fish has an equal probability of being marked in event 1, *or* that every fish has an equal probability of being captured in event 2, *or* that marked fish mix completely with unmarked fish; (b) *both* recruitment and "death" (emigration) do not occur between sampling events; (c) marking does not affect catchability (or mortality) of the fish; (d) fish do not lose their marks between sampling events; (e) all recovered marks are reported; and (f) double sampling does not occur (Seber 1982). Assumption (a) implies that marking must occur in proportion to abundance during immigration, or if it does not, that there is no difference in migratory timing among stocks bound for different spawning locations, since temporal mixing can not occur in the experiment. We attempted to meet assumption (a) by fishing the same gear in a standardized method throughout the chinook salmon migration. Assumption (a) also implies that sampling is not size or sex-selective. If capture on the spawning grounds was not size-selective, fish of different sizes would be captured with equal probability. The same is true for sex-selective sampling on the spawning grounds. If assumption (a) was met, fish sampled in upper Tatshenshini (Blanchard and Goat creeks) and Klukshu River spawning sites and in the recreational fishery would be marked at similar rates. Contingency table analysis was used to test the assumption of proportional tagging. The hypothesis that fish of different sizes were captured with equal probability was also tested using two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.05$). These hypotheses tests and adjustments for bias are described in Appendix C. Assumption (b) was met because the life history of chinook salmon isolates those fish returning to the Alsek River as a "closed" population. We assumed marked and unmarked fish experience the same mortality (assumption c) from natural causes, and censoring was used to adjust the potentially higher harvest rate of marked fish in the U.S. commercial fishery. However, assumption (c) may have been violated with sampling at the Klukshu weir. Tagged fish have a higher probability of being sampled than untagged fish when trap loads of salmon are inspected only when a tagged fish is recognized as being in the load. If all marked fish passing through the weir had kept their tags, and if all passing tagged fish had been recognized, assumption (c) would still have been met.

To minimize effects of tag loss, all marked fish received secondary (a dorsal left opercle punch), and tertiary marks (the left axillary appendage was clipped). Similarly, we inspected all fish captured on the spawning grounds for marks (assumption e), and double sampling was prevented by an additional mark (ventral opercle punch) (assumption f). Variance, statistical bias, and confidence intervals for the abundance estimate were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (1991).

We used the following equations to estimate the expansion factor for counts $C_{W,t}$ at the weir on the Klukshu River into estimates of abundance N_t of large chinook salmon spawning in the Alsek River, where t is year, k is the number of estimates of π, π is the ratio (expansion factor) where i denotes years with mark-recapture experiments:

$$\hat{\pi}_i = \hat{N}_i C_{W,i}^{-1} \quad (1)$$

$$v(\hat{\pi}_i) = v(\hat{N}_i) C_{W,i}^{-2} \quad (2)$$

$$\overline{\pi} = \frac{\sum_{i=1}^{k} \hat{\pi}_i}{k} \quad (3)$$

$$v(\pi) = \frac{\sum_{i=1}^{k} (\hat{\pi}_i - \overline{\pi})^2}{k-1} \quad (4)$$

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

Scales were sampled from all fish captured at the Dry Bay tagging site and during spawning ground surveys and from portions of the Canadian aboriginal and recreational harvests to determine their age (Olsen 1995). Five scales were collected from the preferred area of each fish (Welander 1940), mounted on gum cards and impressions were made in cellulose acetate (Clutter and Whitesel 1956). Age of each fish was determined later from the pattern of circuli on images of scales magnified 70× (Olsen 1995). Samples from Dry Bay were processed at the ADF&G Scale Aging Lab in Douglas, AK, all other samples were processed at the DFO lab in Nanaimo, B.C. All scales were read by at least one staff member, with unusual or questionable scales read again by one or more staff. In 2001, scales collected at the Klukshu River weir were read at both labs.

The proportion of the spawning population composed of a given age within small-medium or large categories of salmon was estimated as a binomial variable from fish sampled on the spawning grounds:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \quad (5)$$

$$v[\hat{p}_{ij}] = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{n_i - 1} \quad (6)$$

where $\hat{p}_{ij}$ is the estimated proportion of the population of age j in size category i, n_{ij} is the number of chinook salmon of age j in size category i, and n_i is the number of chinook salmon in the sample n of size category i taken on the spawning grounds.

Numbers of spawning fish by age j were estimated as the summation of products of estimated age composition and estimated abundance, minus harvest, within a size category i:

$$\hat{N}_j = \sum_i (p_{ij} \hat{N}_i) \quad (7)$$

with a sample variance calculated according to procedures in Goodman (1960):

$$v(\hat{N}_j) = \sum_i \begin{pmatrix} v(\hat{p}_{ij}) \hat{N}_i^2 + v(\hat{N}_i) \hat{p}_{ij} \\ - v(\hat{p}_{ij}) v(\hat{N}_i) \end{pmatrix} \quad (8)$$

The proportion of the spawning population composed of a given age was estimated by:

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}} \quad (9)$$

where $\hat{N} = \sum \hat{N}_i$. Variance of $\hat{p}_j$ was approximated according to procedures in Seber (1982):

$$v(\hat{p}_j) = \frac{\sum_i \left(v(\hat{p}_{ij}) \hat{N}_i^2 + v(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2 \right)}{\hat{N}^2} \quad (10)$$

Sex and age-sex composition for the spawning population and associated variances were also estimated with the equations above by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes sex, such that $\sum_k \hat{p}_k = 1$, and by age-sex, such that $\sum_{jk} \hat{p}_{jk} = 1$.

Age, sex, and age-sex composition and associated variances for the Dry Bay and Alaska commercial fisheries samples were also estimated as described above.

Estimated age composition of chinook salmon captured in the different spawning areas was compared using a chi-square test, prior to combining these samples. Estimated age composition of the gillnet samples was compared with estimated age composition from data pooled across spawning grounds using another chi-square test. Estimates of mean length at age and their estimated variances were calculated with standard normal procedures.

RESULTS

DRY BAY

Between May 13 and August 19, 2001, 589 large (437 in chinook gear, 152 in sockeye gear) and 84 small and medium (38 in chinook gear, 46 in sockeye gear) chinook salmon were captured in the lower Alsek River. Of these, 529 large and 73 medium fish were sampled, marked and released (Table 4, Appendix A1). Set gillnet effort was maintained at 8 hours per day per net, although reduced sampling effort occurred on several days (Figure 3; Appendix A1). Catch rates ranged from 0 to 5.2 fish/net-hour and peaked on June 10, when 46 large chinook were captured (Figure 4). The date of 50% cumulative catch was June 11. The sex ratio of chinook salmon caught in the gillnets was skewed towards females (423 females, 244 males). In addition, each healthy sockeye salmon captured was marked with a spaghetti tag and released as part of separate mark-recapture experiment conducted by Commercial Fisheries Division and DFO (Figure 5 and Appendix A1).

FISHERY SAMPLING

The inriver U.S. commercial gillnet fishery harvested 541 chinook salmon—including 8 tagged fish, and U.S. subsistence and personal use fisheries harvested 19 more (Tables 2, 4).

SPAWNING GROUND SAMPLING

Of the 1,825 chinook salmon observed passing through the Klukshu River weir, 643 were sampled, of which 546 were large fish and 46 were marked (Table 4). Of fish sampled at the weir, 332 were females and 310 males. One tag loss (1.8%) was noted in the sample of fish examined.

The 1,182 fish unsampled chinook salmon passing through the weir were not physically examined (inspected) for marks; however, each fish was carefully observed from a short distance as they passed over a white observation board, and with one major exception all tagged fish are believed to have been observed. The exception occurred on July 17, when a huge pulse of 641 chinook was passed, 611 in a four hour period (Appendix A3). Some tagged fish likely passed unobserved during that period. Size and sex of each fish were not estimated. Forty-three (43) carcasses were sampled at or above the weir, with 2 marked fish recovered.

At Blanchard River, 155 (151 large) live chinook and carcasses were examined for marks, with 8 marked fish recovered (Table 4). At Goat Creek on the upper Tatshenshini River, 18 large chinook salmon were sampled with 0 tags recovered, and on the Takhanne River 54 (50 large) fish were sampled with 2 tags recovered. A foot survey was conducted on Low Fog Creek on Aug 1, seven chinook were observed, none were sampled.

The aboriginal fishery near Dalton Post harvested 112 chinook salmon with one tag reported. The entire catch was not sampled, but all tagged fish harvested are assumed to have been reported because of the close proximity of the DFO camp and signs posted describing the tagging study and reward program. The sport fishery near Dalton Post harvested approximately 112 chinook with additional fish released. Forty

Table 4.–Numbers of chinook salmon marked on lower Alsek River, removed by fisheries and inspected for marks in tributaries in 2001, by length group. Numbers in bold used in mark-recapture estimate.

		Length (MEF)			
		Small 0–439 mm	**Medium 440–659 mm**	**Large ≥660 mm**	**Total**
A. Released at Dry Bay with marks		0	73	529	602
B. Removed by:					
1. U.S. sport/subsistence		0	0	0	0
2. U.S. gillnet		0	3	5	8
Subtotal of removals		0	3	5	8
C. Estimated number of marked fish remaining in mark-recapture experiment		0	70	**524**	594
D. Spawning ground samples					
Observed at Klukshu weir	Observed		179	**1,005**[a]	1,825
	Marked		10	**46**	66
	Marked/observed		0.0559	0.0458	0.0345
Inspected at:					
1a. Klukshu weir live	Inspected		97	546	643
	Marked	0	10	46	56
	Marked/inspected		0.1031	0.0842	0.0871
1b. Klukshu weir carcass	Inspected	0	7	36	43
	Marked	0	1	1	2
	Marked/inspected		0.1429	0.0278	0.0465
2. Blanchard/ Takhanne/Goat	Inspected	0	8	**219**	227
	Marked	0	0	**10**	10
	Marked/ inspected		0.000	0.0457	0.0441
3. Sport fishery	Harvest		1	**39**	40
	Marked		1	**2**	3
	Marked/inspected		1.000	0.0513	0.0750
4. Aboriginal fishery	Harvest			6	6
	Marked			1	1
	Marked/inspected			0.1667	0.1667

[a] Fish passed July 17 (641) removed, size category estimated from inspected sample proportions.

(40) fish were examined by DFO technicians, and 3 tagged fish were recovered or reported.

ABUNDANCE

The mark-recapture estimate for large fish only is 11,246 fish (SE = 1,336). An estimated 524 marked fish moved upstream, 58 of which were found in the 1,263 fish inspected upstream on the spawning grounds or observed at the weir (Table 4). A 95% confidence interval around estimated abundance past Dry Bay from bootstrapping is 9,146–14,303 fish; estimated statistical bias is 1.32%.

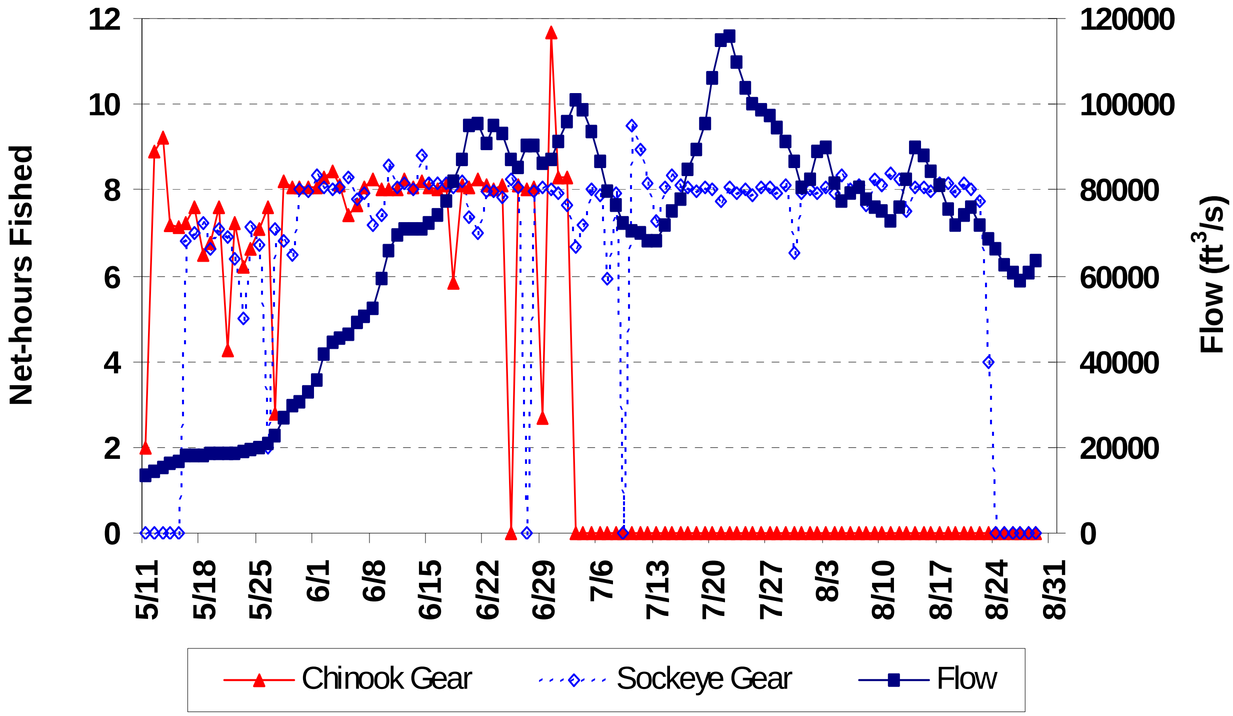

Figure 3.–Daily fishing effort (hours) for chinook (7¼-in.) and sockeye (5¼-in.) gillnets and river flow (ft^3/s), Alsek River near Dry Bay, 2001. Flow information from USGS water information system.

After subtracting the Canadian inriver harvest of 224, which is primarily large fish, the estimated number of large spawners in the entire Alsek River is 11,022 fish.

Samples taken at Blanchard River and Goat Creek, Takhanne River, and from the sport fishery were pooled because their marked fractions are not significantly different (0.050 vs 0.042 vs 0.054, $\chi^2 = 0.070$, df = 2, P = 0.965). The marked fractions of the Blanchard and Takhanne river pooled sample were significantly different from those of fish *inspected* at the Klukshu River weir (0.046 vs 0.084, $\chi^2 = 3.73$, df = 1, P = 0.054). However, the estimated marked fraction for large fish *observed* at the weir, with July 17 counts removed, is the same as that estimated for the pooled Blanchard and Takhanne samples (0.046 vs 0.046, $\chi^2 = 0.0026$, df = 1, P = 0.959). The marked fraction in the sport fish sample was also similar and was included in the analysis (0.051; $\chi^2 = 0.0214$, df = 1, P = 0.883).

The estimated harvest in the aboriginal fisheries was low and sample size was too small to be included in the mark-recapture analysis.

The combined length distributions of medium and large fish marked in Dry Bay were not significantly different from length distributions for fish *recaptured* on the spawning grounds (P = 0.68; Figure 6, bottom), indicating that sampling at the Klukshu weir and other spawning grounds was not size-selective. Length distributions of marked chinook salmon were significantly different from all fish *sampled* on the spawning grounds (P <0.001; Figure 6), suggesting size-selective sampling in event 1. Results are similar when the samples are stratified by length and only large fish included.

Additional evidence from spawning ground sampling also supports the supposition that the tagging operation was size selective within the category of larger fish. Pooled length samples of large fish from the spawning grounds were arbitrarily split into two groups at the median

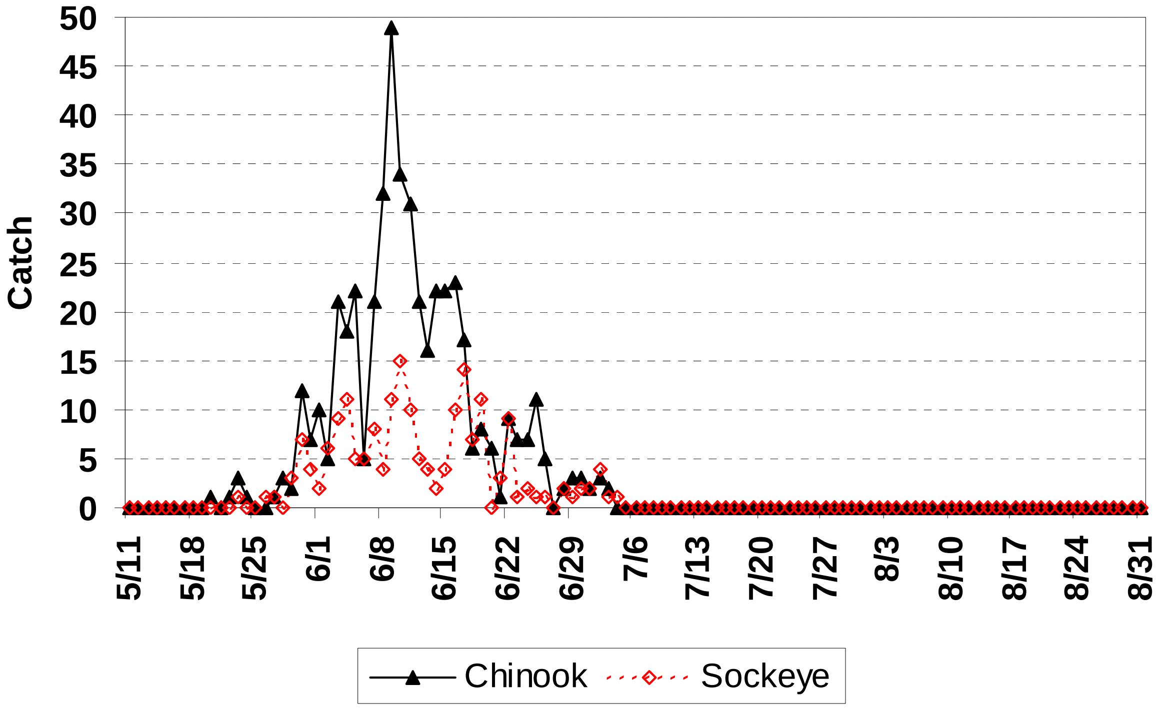

Figure 4.–Daily catch of chinook and sockeye salmon in chinook gillnet, lower Alsek River, 2001.

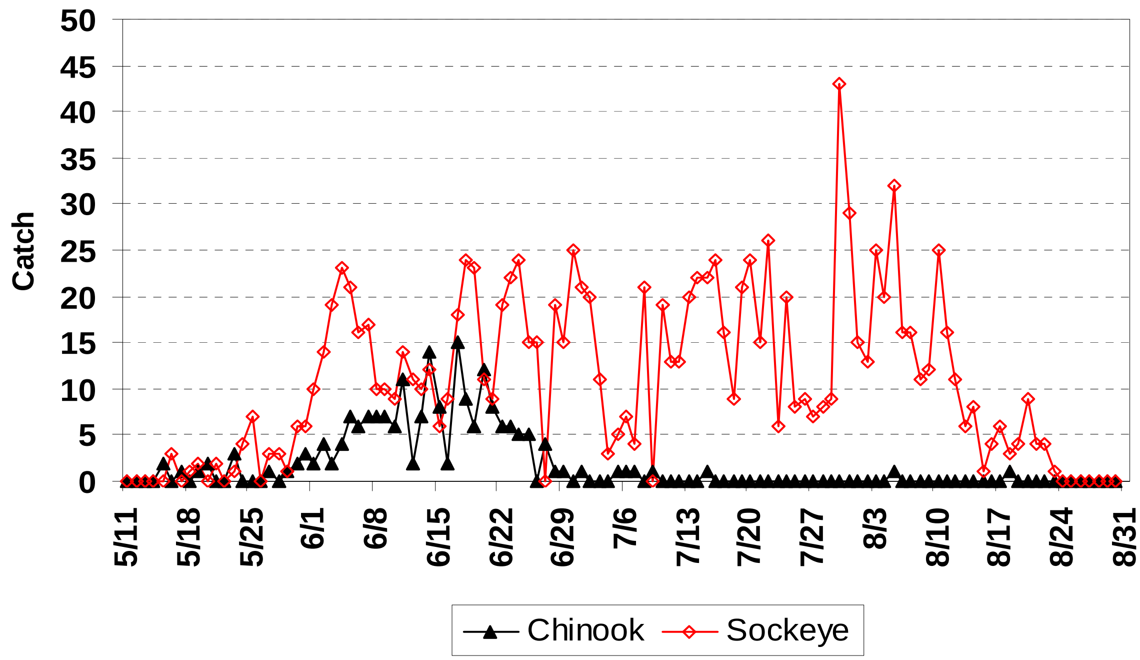

Figure 5.–Daily catch of chinook and sockeye salmon in sockeye gillnet, lower Alsek River, 2001.

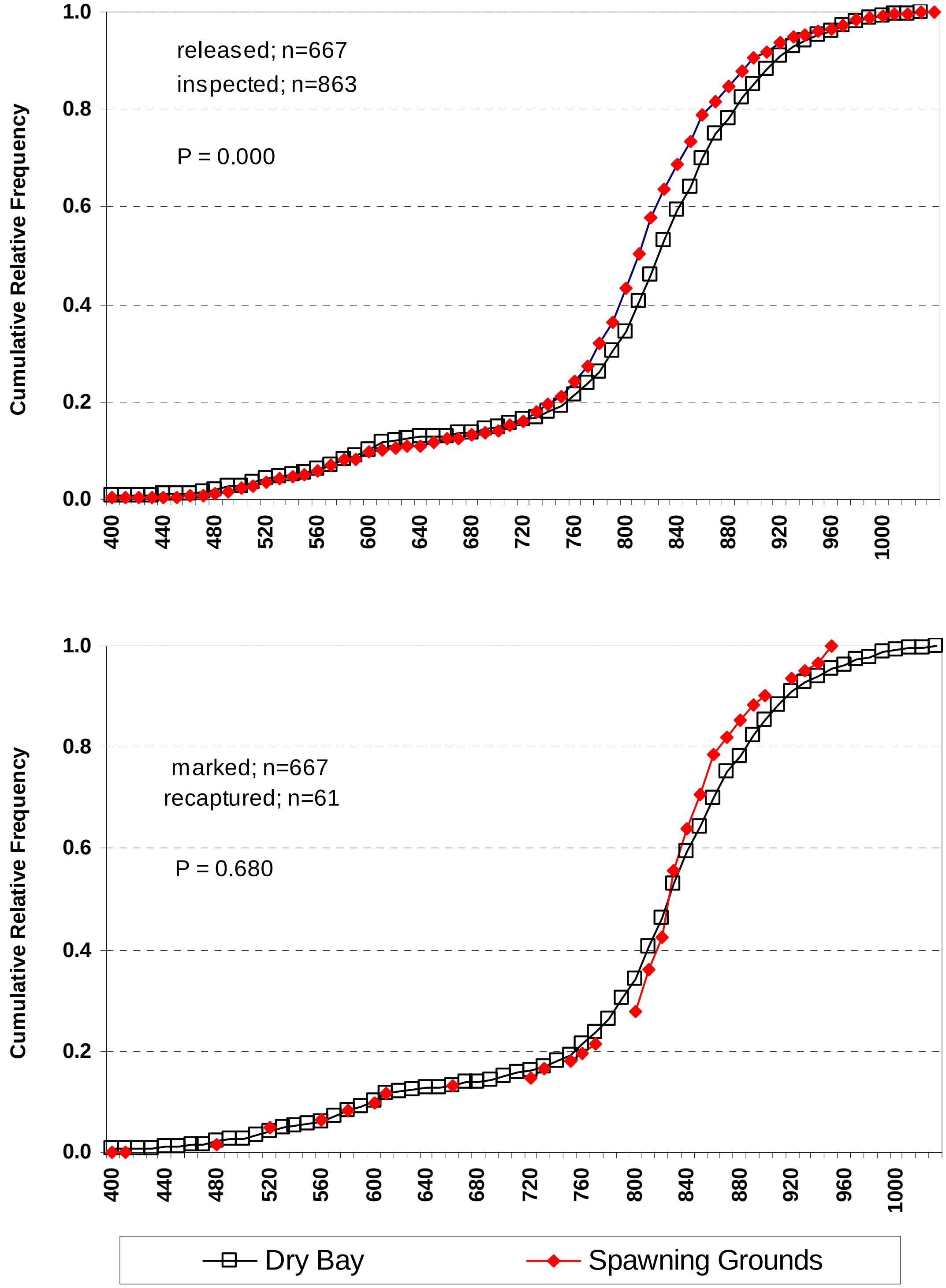

Figure 6.–Cumulative relative frequency of chinook salmon captured in event 1 (Dry Bay gillnet) and marked chinook salmon recaptured in event 2 (spawning ground sampling, Klukshu weir), Alsek River, 2001.

length of large fish (835 mm MEF) to permit comparison of marked fractions:

	660–835 mm	>835 mm
Marked	28	26
Unmarked	439	263
Marked fraction	0.064	0.099

However, these marked fractions were not significantly different (χ^2 = 2.424, df = 1, P = 0.119).

Evidence from spawning ground sampling supports the supposition that every large chinook salmon had a nearly equal chance of being captured upriver regardless of their size. Pooled length samples of large fish from the spawning grounds were again split into two size groups as were samples of larger fish marked in Dry Bay. After censoring large fish removed by the U.S. gillnet fishery, the rates of recaptured fish were compared as surrogates for probabilities of capture upstream:

	660–835 mm	>835 mm
Released	288	294
Recaptured	25	24
Fraction	0.087	0.082

These fractions recaptured were not significantly different (χ^2 = 0.043, df = 1, P = 0.836).

Thus, there is evidence of size-selectivity during the first sampling event in Dry Bay, and only length, sex and age data from the second sampling event on the spawning grounds is used for estimating proportions in compositions (Appendix C1). There were not enough tag recoveries to estimate abundance of medium fish, but a single unstratified abundance estimate could be calculated for medium and large chinook salmon combined. An estimated 12,885 (SE = 1,438; M = 594, R = 66, C = 1,450) large and medium chinook salmon passed upstream of Dry Bay in 2001. The 95% CI is 10,371–16,265 fish; estimated statistical bias is 1.02%.

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

Age 1.3 chinook salmon were again the most common in all samples, constituting an estimated 63% of fish sampled in Dry Bay, 71% at the weir across the Klukshu River, and 65% at Blanchard River/Takhanne/Goat Creek, (Appendix A3–A8). Age 1.4 fish were the second most common, and age 1.2 fish third. Sampled populations were an estimated 37–56% males.

Estimated age compositions were significantly different for fish sampled at Dry Bay and at the Klukshu River (χ^2 = 9.327, df = 2, P = 0.009). Estimated age composition of fish in the Klukshu River sample differed from estimates for fish at the other spawning ground locations (χ^2 = 26.733, df = 2, P <0.001); however, estimated age composition of all spawning ground samples pooled differed only slightly from the fish tagged at Dry Bay (χ^2 = 3.157, df = 2, P = 0.206). Because there is evidence of size-selectivity during the first sampling event in Dry Bay, only the pooled spawning ground samples are used to estimate length, sex and age composition. Abundance of small and medium chinook salmon was estimated as described in Appendix C2, and estimated abundance by age and sex of the entire escapement is calculated in Table 5. The resulting estimate of total escapement, 12,790 fish, is very close to the unstratified mark-recapture estimate of 12,885 fish.

In previous years' studies, most of the scales collected from the Canadian spawning grounds were aged at the Pacific Biological Station Aging Lab in Nanaimo, B.C., and scales collected at the tagging site in Alaska were aged at the ADF&G Aging Lab in Juneau. In 2001, scales collected at the Klukshu River weir were processed at both labs and the estimated age compositions were not significantly different (Appendix A8).

DISCUSSION

Using smaller mesh gillnets in 2001 to eliminate size-selective sampling at Dry Bay was partially effective. In previous studies, the large mesh (7¼-in.) gillnets used in the tagging operation were selective towards larger fish, and that required that the mark-recapture analysis be stratified by size. In 2000, smaller mesh sockeye salmon gear was fished in addition to the larger chinook gear, and spawning ground samples were collected with various gear from pre-

Table 5.–Estimated abundance and composition by age and sex of the escapement of chinook salmon in the Alsek River, 2001.

		Brood year and age class									
		1998	1997	1997	1996	1996	1995	1995	1994	1994	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
Males	n	2	0	55	0	182	1	72	0	2	314
	%	0.3	0.0	9.0	0.0	28.5	0.2	11.3	0.0	0.3	49.6
	SE of %	0.2	0.0	2.7	0.0	1.9	0.2	1.3	0.0	0.2	2.5
	Escapement	42	0	1,147	0	3,650	20	1,441	0	40	6,339
	SE of esc.	21	0	137	0	477	0	191	0	0	764
Females	n	0	0	5	0	258	0	59	0	0	322
	%	0.0	0.0	0.8	0.0	40.4	0.0	9.2	0.0	0.0	50.4
	SE of %	0.0	0.0	0.4	0.0	2.3	0.0	1.2	0.0	0.0	2.5
	Escapement	0	0	103	0	5,167	0	1,181	0	0	6,450
	SE of esc.	0	0	48	0	648	0	201	0	0	786
Sexes	n	2	0	60	0	440	1	131	0	2	636
combined	%	0.3	0.0	9.8	0.0	68.9	0.2	20.5	0.0	0.3	100.0
	SE of %	0.2	0.0	2.8	0.0	2.6	0.2	1.8	0.0	0.2	0.0
	Escapement	42	0	1,250	0	8,817	20	2,621	0	40	12,790
	SE of esc.	31	0	377	0	1,038	20	370	0	28	1,417

spawning and post-spawning fish and carcasses. These changes decreased the size selectivity observed in previous years and eliminated the need to stratify the population estimate by size. In 2001, an additional net of sockeye gear was fished throughout the entire project, nearly doubling the hours fished. Not surprisingly, the smaller gear caught more jack chinook (46 compared to 38 in the chinook gear), and fewer large chinook (152 vs 437). However, the length composition of the large chinook salmon caught in the sockeye gear did not differ from that of those caught in the chinook gear (K-S test, P = 2.966) ($\chi^2 = 2.182$, df = 1, p = 0.1396):

	660–835 mm	>835 mm
Sockeye gear	65	82
Chinook gear	223	212

Although most fish observed in the second event of the mark-recapture experiment were not physically handled, there was no evidence that significant numbers of marked fish were not recognized as such. The blue tag used in the study was designed to prevent predators from targeting on marked fish. Our experience with these tags is that they were easy to see when small numbers of fish passed through the weir. When high numbers of fish passed in a short period it was impossible for the weir crew to sample them all or even observe all the tags. On July 17, 2001 over 600 chinook salmon and 73 sockeye were passed in a 4-hour period, and only 10 tags observed. That was far below the tagging rate observed in other spawning ground samples or at the weir before or after that day, so that day's counts were removed from the mark-recapture calculation.

Differences in migratory timing of stocks within the Alsek River did not follow trends observed for other stocks in other rivers. A tagging study conducted in 1998 used radiotelemetry to estimate the distribution and migratory timing of spawning chinook salmon in the Alsek and Tatshenshini rivers (Pahlke et al. 1999). About 46% of the spawning fish were tracked to areas in the lower and middle Tatshenshini River, downstream from the mouth of the Klukshu River. These fish spawn primarily in glacial waters where they are difficult to see or sample. Studies on the Taku, Stikine, Unuk and Chickamin rivers have shown, in general, chinook salmon migrating to lower tributaries migrated upriver later in the year than fish heading to spawning areas much farther upriver (Pahlke and Bernard 1996; Pahlke and Etherton 1999; Pahlke et al. 1996; Pahlke 1997). That trend was not apparent in the Alsek River study, with fish spawning in the lower and middle Tatshenshini River, and those heading to the upper Tatshenshini River, including the Klukshu, Blanchard, Takhanne rivers and Goat Creek; all passing through Dry Bay in a similar pattern. With no significant differences in run timing, it would be unlikely that fish going to different tributaries would be marked at different rates.

Traditional indicators of chinook salmon escapement to the Alsek River indicate a below average escapement in 2001. The count at the Klukshu weir was above the count in 2000 and within the escapement goal range, but below the recent 10-year average of 2,807. Index counts in the Blanchard and Takhanne rivers were above average. The number of large chinook salmon tagged at the set nets in Dry Bay increased from 245 in 1998, 402 in 1999, 479 in 2000, to 529 in 2001 due to the experience gained in operation of the nets the previous three years and the addition of the sockeye gear. Numbers of fish sampled at the Klukshu River weir and at the other recovery sites were the highest since the inception of the mark-recapture project.

In 2001, 84.3% of the fish inspected at the weir were large fish, resulting in an estimated escapement through the weir of 1,538 large chinook salmon. This was about 14% of the mark-recapture estimated escapement of large fish, or an expansion factor ($\hat{\pi}_i$) of 7.17 (SE = 0.87). Expansion factors $\hat{\pi}_i$ for 1998, 1999, and 2000 were estimated at 6.33 (SE = 1.38), 6.97 (SE = 1.74), and 6.81 (SE = 1.31) respectively. The average over these four estimates is $\bar{\pi} = 6.82$ and its estimated variance $v(\bar{\pi}) = 0.13$ (SE = 0.36).

CONCLUSION AND RECOMMENDATIONS

This was the fourth attempt at estimating the total escapement of chinook salmon to the Alsek River. It appears feasible to conduct a mark-recapture experiment with acceptable results using methods developed in 1997 and 1998. Set gillnets are an effective method of capturing large chinook salmon migrating up the Alsek River, although the tagging crew must respond to fluctuating river conditions which rapidly change the effectiveness of the gear. Sample sizes in both events 1 and 2 must be increased to achieve an acceptably precise estimate of abundance, and the samples at the Klukshu River should be collected in a more systematic manner from all fish passing through the weir, not just those fish that happen to be passing by alongside tagged individuals.

The results of the study indicate that the Klukshu River weir is a valid index of chinook salmon escapement to the Alsek River.

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APPENDIX A:

GILLNET AND WEIR CATCHES
AND AGE, SEX AND LENGTH SUMMARIES

Appendix A1.–Gillnet (chinook gear, 7¼ in.) daily effort (hours fished), catches, cumulative catches, and catch per net hour, near Dry Bay, lower Alsek River, 2001.

Date	Net hours	Large chinook	Large chinook cumul.	Large tagged	Large tagged cumul.	Cumulative percent	CPUE	Jacks	Cumulative jacks tagged	Sockeye caught
5/12/01			0			0				
5/13/01	2.0	0	0	0	0	0	0.00	0	0	0
5/14/01	8.9	0	0	0	0	0	0.00	0	0	0
5/15/01	9.2	0	0	0	0	0	0.00	0	0	0
5/16/01	7.2	0	0	0	0	0	0.00	0	0	0
5/17/01	7.1	0	0	0	0	0	0.00	0	0	0
5/18/01	7.2	0	0	0	0	0	0.00	0	0	0
5/19/01	7.6	0	0	0	0	0	0.00	0	0	0
5/20/01	6.5	1	1	1	1	0	0.15	0	0	0
5/21/01	6.8	0	1	0	1	0	0.00	0	0	0
5/22/01	7.6	1	2	1	2	0	0.13	0	0	0
5/23/01	4.3	3	5	3	5	1	0.71	0	0	1
5/24/01	7.2	1	6	1	6	1	0.14	0	0	0
5/25/01	6.2	0	6	0	6	1	0.00	0	0	0
5/26/01	6.6	0	6	0	6	1	0.00	0	0	1
5/27/01	7.1	1	7	1	7	2	0.14	0	0	1
5/28/01	7.6	3	10	3	10	2	0.39	0	0	0
5/29/01	2.8	2	12	2	12	3	0.72	0	0	3
5/30/01	8.2	12	24	12	24	5	1.46	0	0	7
5/31/01	8.1	7	31	7	31	7	0.87	0	0	4
6/1/01	8.1	9	40	9	40	9	1.11	1	1	2
6/2/01	8.1	5	45	4	44	10	0.62	0	1	6
6/3/01	8.1	20	65	18	62	15	2.47	1	2	9
6/4/01	8.3	18	83	16	78	19	2.17	0	2	11
6/5/01	8.4	20	103	20	98	24	2.38	2	4	5
6/6/01	8.1	5	108	5	103	25	0.62	0	4	5
6/7/01	7.4	19	127	19	122	29	2.57	2	5	8
6/8/01	7.7	29	156	28	150	36	3.78	3	8	4
6/9/01	8.1	42	198	35	185	45	5.21	7	15	11
6/10/01	8.2	32	230	26	211	53	3.89	2	17	15
6/11/01	8.0	29	259	24	235	59	3.63	2	19	10
6/12/01	8.0	17	276	16	251	63	2.12	4	22	5
6/13/01	8.0	15	291	14	265	67	1.88	1	23	4
6/14/01	8.3	20	311	19	284	71	2.42	2	25	2
6/15/01	8.1	18	329	17	301	75	2.23	4	28	4
6/16/01	8.2	21	350	18	319	80	2.56	2	29	10
6/17/01	8.1	15	365	14	333	84	1.86	2	31	14
6/18/01	8.0	6	371	5	338	85	0.75	0	31	7
6/19/01	8.1	8	379	8	346	87	0.99	0	31	11
6/20/01	5.9	6	385	4	350	88	1.03	0	31	0
6/21/01	8.1	1	386	1	351	88	0.12	0	31	3
6/22/01	8.1	8	394	5	356	90	0.99	1	32	9
6/23/01	8.2	6	400	6	362	92	0.73	1	32	1
6/24/01	8.1	6	406	6	368	93	0.74	1	32	2
6/25/01	8.0	11	417	8	376	95	1.38	0	32	1
6/26/01	8.1	5	422	5	381	97	0.62	0	32	1
6/27/01	0.0	0	422	0	381	97	0.00	0	32	0
6/28/01	8.1	2	424	2	383	97	0.25	0	32	2
6/29/01	8.0	3	427	3	386	98	0.37	0	32	1
6/30/01	8.1	3	430	1	387	98	0.37	0	32	2
7/1/01	2.7	2	432	2	389	99	0.75	0	32	2
7/2/01	11.7	3	435	2	391	100	0.26	0	32	4
7/3/01	8.3	2	437	2	393	100	0.24	0	32	1
7/4/01	8.3	0	437	0	393			0	32	1
7/5/01	0.0				393				32	
7/6/01	0.0				393				32	
7/7/01	0.0				393				32	
7/8/01	0.0				393				32	
7/9/01	0.0				393				32	
7/10/01	0.0				393				32	

Appendix A2.–Gillnet (sockeye gear, 5¼ in.) daily effort (hours fished), catches, cumulative catches, and river flow (ft^3/s) near Dry Bay, lower Alsek River, 2001.

Date	Flow	Net hours	Large chinook	Large tagged	Cumulative large tagged	Jacks caught	Jacks tagged	Cumulative jacks tagged	Sockeye caught
5/11/01	12700	0							
5/12/01	13300	0							
5/13/01	14400	0							
5/14/01	15400	0							
5/15/01	16200	0							
5/16/01	16900	6.8	2	2	2	0	0	0	3
5/17/01	17900	7.0	0	0	2	0	0	0	0
5/18/01	18000	7.3	1	1	3	0	0	0	1
5/19/01	18200	6.6	0	0	3	0	0	0	2
5/20/01	18500	7.1	1	1	4	0	0	0	0
5/21/01	18400	6.9	2	1	5	0	0	0	2
5/22/01	18500	6.4	0	0	5	0	0	0	0
5/23/01	18600	5.0	0	0	5	0	0	0	1
5/24/01	18800	7.1	2	2	7	1	1	1	4
5/25/01	19300	6.7	0	0	7	0	0	1	7
5/26/01	19900	2.0	0	0	7	0	0	1	0
5/27/01	20700	7.1	0	0	7	0	0	1	3
5/28/01	22900	6.8	1	1	8	0	0	1	3
5/29/01	26900	6.5	0	0	8	0	0	1	1
5/30/01	29600	8.0	0	0	8	1	1	2	6
5/31/01	30700	8.0	2	2	10	0	0	2	6
6/1/01	33000	8.3	3	3	13	0	0	2	10
6/2/01	35800	8.1	2	2	15	0	0	2	14
6/3/01	41600	8.0	4	4	19	0	0	2	19
6/4/01	44300	8.1	2	2	21	0	0	2	23
6/5/01	45600	8.3	4	4	25	0	0	2	21
6/6/01	46200	7.8	6	5	30	1	1	3	16
6/7/01	48900	7.9	6	6	36	0	0	3	17
6/8/01	50400	7.2	6	4	40	1	0	3	10
6/9/01	52500	7.4	4	4	44	3	3	6	10
6/10/01	59100	8.6	4	3	47	3	3	9	9
6/11/01	65700	8.1	6	5	52	0	0	9	14
6/12/01	69400	8.2	8	7	59	3	2	11	11
6/13/01	70700	8.0	2	2	61	0	0	11	10
6/14/01	70800	8.8	6	5	66	1	1	12	12
6/15/01	70900	8.1	9	7	73	5	4	16	6
6/16/01	72200	8.1	5	4	77	3	2	18	9
6/17/01	73900	8.2	2	2	79	0	0	18	18
6/18/01	77400	8.1	12	11	90	3	3	21	24
6/19/01	81800	8.2	9	9	99	0	0	21	23
6/20/01	87100	7.4	4	4	103	2	1	22	11
6/21/01	95000	7.0	7	7	110	5	5	27	9
6/22/01	95300	8.0	2	2	112	6	6	33	19
6/23/01	91000	8.0	5	4	116	1	1	34	22
6/24/01	95000	7.9	3	3	119	3	3	37	24
6/25/01	93100	8.2	4	4	123	1	1	38	15
6/26/01	87000	8.1	5	5	128	0	0	38	15
6/27/01	85400	0.0	0	0	128	0	0	38	0
6/28/01	90400	8.0	1	1	129	3	3	41	19
6/29/01	90400	8.1	1	0	129	0	0	41	15
6/30/01	86100	8.0	1	1	130	0	0	41	25
7/1/01	87300	7.9	0	0	130	0	0	41	21
7/2/01	91100	7.7	1	1	131	0	0	41	20
7/3/01	95900	6.7	0	0	131	0	0	41	11
7/4/01	101000	7.2	0	0	131	0	0	41	3
7/5/01	98600	8.0	0	0	131	0	0	41	5
7/6/01	93600	7.9	1	1	132	0	0	41	7
7/7/01	86800	6.0	1	0	132	0	0	41	4
7/8/01	79900	7.9	1	0	132	0	0	41	21

-continued-

Appendix A2.–Page 2 of 2.

Date	Flow	Net hours	Large chinook	Large tagged	Cumulative large tagged	Jacks caught	Jacks tagged	Cumulative jacks tagged	Sockeye caught
7/9/01	76300	0.0	0	0	132	0	0	41	0
7/10/01	72400	9.5	1	1	133	0	0	41	19
7/11/01	70500	9.0	0	0	133	0	0	41	13
7/12/01	70100	8.2	0	0	133	0	0	41	13
7/13/01	68200	7.3	0	0	133	0	0	41	20
7/14/01	68200	8.1	0	0	133	0	0	41	22
7/15/01	72000	8.3	0	0	133	0	0	41	22
7/16/01	75000	8.1	1	1	134	0	0	41	24
7/17/01	78000	8.1	0	0	134	0	0	41	16
7/18/01	85000	8.0	0	0	134	0	0	41	9
7/19/01	89400	8.1	0	0	134	0	0	41	21
7/20/01	95400	8.0	0	0	134	0	0	41	24
7/21/01	106000	7.8	0	0	134	0	0	41	15
7/22/01	115000	8.1	0	0	134	0	0	41	26
7/23/01	116000	7.9	0	0	134	0	0	41	6
7/24/01	110000	8.0	0	0	134	0	0	41	20
7/25/01	104000	7.9	0	0	134	0	0	41	8
7/26/01	100000	8.1	0	0	134	0	0	41	9
7/27/01	98900	8.1	0	0	134	0	0	41	7
7/28/01	97100	7.9	0	0	134	0	0	41	8
7/29/01	94400	8.1	0	0	134	0	0	41	9
7/30/01	91100	6.5	0	0	134	0	0	41	43
7/31/01	86700	7.9	0	0	134	0	0	41	29
8/1/01	80500	8.0	0	0	134	0	0	41	15
8/2/01	82400	7.9	0	0	134	0	0	41	13
8/3/01	89100	8.1	0	0	134	0	0	41	25
8/4/01	90100	7.9	0	0	134	0	0	41	20
8/5/01	81400	8.4	0	0	134	0	0	41	32
8/6/01	77500	8.0	1	1	135	0	0	41	16
8/7/01	79000	8.1	0	0	135	0	0	41	16
8/8/01	80400	7.6	0	0	135	0	0	41	11
8/9/01	77800	8.2	0	0	135	0	0	41	12
8/10/01	75900	8.1	0	0	135	0	0	41	25
8/11/01	75100	8.4	0	0	135	0	0	41	16
8/12/01	72600	8.3	0	0	135	0	0	41	11
8/13/01	76200	7.5	0	0	135	0	0	41	6
8/14/01	82300	8.1	0	0	135	0	0	41	8
8/15/01	89900	8.1	0	0	135	0	0	41	1
8/16/01	87800	8.0	0	0	135	0	0	41	4
8/17/01	84300	8.2	0	0	135	0	0	41	6
8/18/01	81100	8.1	0	0	135	0	0	41	3
8/19/01	75500	8.0	1	1	136	0	0	41	4
8/20/01	71900	8.2	0	0	136	0	0	41	9
8/21/01	74100	8.0	0	0	136	0	0	41	4
8/22/01	75800	7.7	0	0	136	0	0	41	4
8/23/01	72000	4.0	0	0	136	0	0	41	1
8/24/01	68600				136			41	
Total			152			46			1,226

Appendix A3.–Daily and cumulative counts of Klukshu River sockeye and chinook salmon through the Klukshu River weir, and chinook salmon sampled and tags observed, 2001.

Date	Sockeye daily	Chinook daily	Daily proportion	Chinook cumulative	Cumulative proportion	Number sampled daily	Cumulative number sampled	Tags observed	Tags sampled
25-Jun	2					0	0		
26-Jun	1	1	0.001	1	0.001	1	1		
27-Jun	1	2	0.001	3	0.002	2	3		
28-Jun	0	3	0.002	6	0.003	3	6		
29-Jun	0	5	0.003	11	0.006	5	11		
30-Jun	3	0	0.000	11	0.006	0	11		
1-Jul	4	4	0.002	15	0.008	4	15		
2-Jul	2	2	0.001	17	0.009	2	17		
3-Jul	0	2	0.001	19	0.010	2	19		
4-Jul	2	2	0.001	21	0.012	2	21		
5-Jul	3	2	0.001	23	0.013	2	23	1	1
6-Jul	3	2	0.001	25	0.014	2	25		
7-Jul	0	4	0.002	29	0.016	4	29		
8-Jul	3	1	0.001	30	0.016	1	30		
9-Jul	5	2	0.001	32	0.018	2	32		
10-Jul	1	4	0.002	36	0.020	4	36		
11-Jul	2	3	0.002	39	0.021	3	39		
12-Jul	0	8	0.004	47	0.026	8	47		
13-Jul	3	11	0.006	58	0.032	11	58		
14-Jul	3	21	0.012	79	0.043	21	79	1	1
15-Jul	6	22	0.012	101	0.055	17	96		
16-Jul	11	44	0.024	145	0.079	22	118	1	1
17-Jul	90	641	0.351	786	0.431	19	137	10	1
18-Jul	14	37	0.020	823	0.451	17	154	1	1
19-Jul	11	55	0.030	878	0.481	14	168		
20-Jul	18	18	0.010	896	0.491	15	183		
21-Jul	45	37	0.020	933	0.511	29	212		
22-Jul	105	98	0.054	1031	0.565	44	256	4	4
23-Jul	21	50	0.027	1081	0.592	29	285	1	1
24-Jul	13	70	0.038	1151	0.631	23	308	3	3
25-Jul	6	27	0.015	1178	0.645	23	331	3	3
26-Jul	7	39	0.021	1217	0.667	24	355	2	2
27-Jul	8	45	0.025	1262	0.692	23	378	2	2
28-Jul	3	46	0.025	1308	0.717	30	408	2	2
29-Jul	4	50	0.027	1358	0.744	25	433	1	1
30-Jul	8	44	0.024	1402	0.768	26	459	3	3
31-Jul	4	18	0.010	1420	0.778	17	476	2	2
1-Aug	9	69	0.038	1489	0.816	25	501	7	7
2-Aug	83	110	0.060	1599	0.876	9	510	1	1
3-Aug	10	31	0.017	1630	0.893	13	523	3	3
4-Aug	7	13	0.007	1643	0.900	13	536		
5-Aug	4	10	0.005	1653	0.906	10	546	2	2
6-Aug	6	19	0.010	1672	0.916	18	564		
7-Aug	20	12	0.007	1684	0.923	9	573	2	2
8-Aug	43	8	0.004	1692	0.927	5	578		
9-Aug	2	6	0.003	1698	0.930	5	583		
10-Aug	5	2	0.001	1700	0.932	2	585	2	2
11-Aug	5	1	0.001	1701	0.932	1	586		
12-Aug	7	4	0.002	1705	0.934	2	588		
13-Aug	197	4	0.002	1709	0.936	4	592		
14-Aug	84	9	0.005	1718	0.941	4	596		
15-Aug	14	11	0.006	1729	0.947	10	606	1	1
16-Aug	340	25	0.014	1754	0.961	8	614	2	2
17-Aug	9	4	0.002	1758	0.963	4	618		
18-Aug	10	8	0.004	1766	0.968	8	626	2	2
19-Aug	4	12	0.007	1778	0.974	12	638	1	1
20-Aug	7	5	0.003	1783	0.977	5	643	2	2
21-Aug	20	0	0.000	1783	0.977	0	643		
22-Aug	114	3	0.002	1786	0.979	2	645		

-continued-

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Date	Sockeye daily	Chinook daily	Daily proportion	Chinook cumulative	Cumulative proportion	Number sampled daily	Cumulative number sampled	Tags observed	Tags sampled
23-Aug	771	16	0.009	1802	0.987	5	650	1	1
24-Aug	827	14	0.008	1816	0.995	0	650		
25-Aug	543	0	0.000	1816	0.995	0	650		
26-Aug	263	1	0.001	1817	0.996	1	651		
27-Aug	555	2	0.001	1819	0.997	0	651		
28-Aug	144	0	0.000	1819	0.997	0	651		
29-Aug	115	0	0.000	1819	0.997	0	651		
30-Aug	2003	0	0.000	1819	0.997	0	651		
31-Aug	241	0	0.000	1819	0.997	0	651		
1-Sep	45	1	0.001	1820	0.997	1	652		
2-Sep	540	1	0.001	1821	0.998	1	653		
3-Sep	24	0	0.000	1821	0.998	0	653		
4-Sep	35	4	0.002	1825	1.000	1	654		
5-Sep	17	0	0.000	1825	1.000	0	654		
6-Sep	33	0	0.000	1825	1.000	0	654		
7-Sep	109	0	0.000	1825	1.000	0	654		
8-Sep	97	0	0.000	1825	1.000	0	654		
9-Sep	352	0	0.000	1825	1.000	1	655		
10-Sep	40	0	0.000	1825	1.000	0	655		
11-Sep	62	0	0.000	1825	1.000	0	655		
12-Sep	11	0	0.000	1825	1.000	0	655		
13-Sep	1496	0	0.000	1825	1.000	0	655		
14-Sep	104	0	0.000	1825	1.000	0	655		
15-Sep	32	0	0.000	1825	1.000	0	655		
16-Sep	11	0	0.000	1825	1.000	0	655		
17-Sep	7	0	0.000	1825	1.000	0	655		
18-Sep	0	0	0.000	1825	1.000	0	655		
19-Sep	2	0	0.000	1825	1.000	0	655		
20-Sep	0	0	0.000	1825	1.000	0	655		
21-Sep	2	0	0.000	1825	1.000	0	655		
22-Sep	2	0	0.000	1825	1.000	0	655		
23-Sep	0	0	0.000	1825	1.000	0	655		
24-Sep	4	0	0.000	1825	1.000	0	655		
25-Sep	4	0	0.000	1825	1.000	0	655		
26-Sep	1	0	0.000	1825	1.000	0	655		
27-Sep	18	0	0.000	1825	1.000	0	655		
28-Sep	29	0	0.000	1825	1.000				
29-Sep	8	0	0.000	1825	1.000				
30-Sep	11	0	0.000	1825	1.000				
1-Oct	3	0	0.000	1825	1.000				
2-Oct	20	0	0.000	1825	1.000				
3-Oct	4	0	0.000	1825	1.000				
4-Oct	37	0	0.000	1825	1.000				
5-Oct	51	0	0.000	1825	1.000				
6-Oct	27	0	0.000	1825	1.000				
7-Oct	2	0	0.000	1825	1.000				
8-Oct	4	0	0.000	1825	1.000				
9-Oct	2	0	0.000	1825	1.000				
10-Oct	0	0	0.000	1825	1.000				
11-Oct	0	0	0.000	1825	1.000				
12-Oct	1	0	0.000	1825	1.000				
13-Oct	2	0	0.000	1825	1.000				
14-Oct	1	0	0.000	1825	1.000				
15-Oct	0	0	0.000	1825	1.000				
16-Oct	0	0	0.000	1825	1.000				
17-Oct	0	0	0.000	1825	1.000				
	10,124	1,825	1.000						
Adjustments a)									
Total	10,290					655	655	63	54

Appendix A4.–Estimated age composition and mean length of chinook salmon in the Dry Bay set gillnet catch by sex and age class, 2001.

		Brood year and age class									
		1998	1997	1997	1996	1996	1995	1995	1994	1994	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Males	n	6	41	0	109	0	64	3	1	0	224
	%	2.7	18.3		48.7		28.6	1.3	0.4		36.9
	SE of %	1.1	2.6		3.3		3.0	0.8	0.4		2.0
	Avg. length	379	561		816		940	892	1,010		
	SD length	69.1	64		86		54	34	0		
	SE length	28	10		85	7	20		0		
Females	n		24		273		78	7	0	1	383
	%		6.3		71.3		20.4	1.8		0.3	63.1
	SE of %		1.2		2.3		2.1	0.7		0.3	2.0
	Avg. length		568		812		889	821		880	
	SD length		54		44		36	54			
	SE of esc.		11		3		4	20	0		
Sexes combined	n	6	65		382		142	10	1	1	607
	%	1.0	10.7		62.9		23.4	1.6	0.2	0.2	100.0
	SE of %	0.4	1.3		2.0		1.7	0.5	0.2	0.2	
	Avg. length	379	564		813		911	842	1,010	880	
	SD length	69.1	60		59		51	58			
	SE length	28	7		3		4	18			

Appendix A5.–Estimated age composition and mean length of chinook salmon in the Klukshu River, by sex and age class, 2001.

		Brood year and age class									
		1998	1997	1997	1996	1996	1995	1995	1994	1994	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Males	n	1	49	0	121	0	33	0	1	0	205
	%	0.5	23.9	0	59.0		16.1		0.5		46.6
	SE of %	0.5	3.0		3.4		3.4		2.6		2.4
	Avg. length	326	547		793		899		974		
	SD length		48		75		75				
	SE length		7		7		12				
Females	n	0	5	0	192	0	38	0	0	0	235
	%		2.1		81.7		16.2				53.4
	SE of %		0.9		2.5		2.4				2.4
	Avg. length		595		798		854				
	SD length		196		54		49				
	SE of esc.		88		4		8				
Sexes combined	n	1	54	0	313	0	71	0	1	0	440
	%	0.2	12.3		71.1		16.1		0.2		100.0
	SE of %	0.2	1.6		2.2		1.8		0.2		
	Avg. length	326	552		796		875		974		
	SD length		72		63		63				
	SE length		10		4		8				

Appendix A6.–Estimated age composition and mean length of chinook salmon in the Blanchard and Takhanne rivers and Goat Creek, by sex and age class, 2001

		Brood year and age class									
		1998	1997	1997	1996	1996	1995	1995	1994	1994	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Males	n	1	6	0	61	0	39	1	1	0	109
	%	0.9	5.5		56.0		35.8	0.9	0.9		55.6
	SE of %	0.9	2.2		4.8		4.6	0.9	0.9		3.6
	Avg. length	340	550		824		939	860	880		
	SD length		63		67		57		0		
	SE length		23		9		9				
Females	n	0	0	0	66	0	21	0	0	0	87
	%				75.9		24.1				44.4
	SE of %				4.6		4.6				3.6
	Avg. length				806		877				
	SD length				37		35				
	SE of esc.				5		8				
Sexes	n	0	6	0	127	0	60	1	1	0	196
combined	%		3.1		64.8		30.6	0.5	0.5		100.0
	SE of %		1.2		3.4		3.3	0.5	0.5		0.0
	Avg. length		550		815		917	860	880		
	SD length		63		54		58				
	SE length		26		5		8				

Appendix A7.–Estimated age composition and mean length of chinook salmon harvested in the Dry Bay commercial set net fishery, by sex and age class, 2001.

		Brood year and age class									
		1998	1997	1997	1996	1996	1995	1995	1994	1994	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Males	n	0	26	0	25	0	7	0	0	0	58
	%		44.8		43.1		12.1				43.6
	SE of %		6.6		6.6		4.3				4.3
	Avg. length		626		852		919				
	SE length		53		15		20				
Females	n	0	5	0	57	0	13	0	0	0	75
	%		6.7		76.0		17.3				56.4
	SE of %		2.9		5.0		4.4				4.3
	Avg. length		637		799		890				
	SE of esc.		27		7		21				
Sexes	n	0	31	0	82	0	20	0	0	0	133
combined	%		23.3		61.7		15.0				100.0
	SE of %		3.7		4.2		3.1				0.0
	Avg. length		628		815		906				
	SE length		41		7		14				

Appendix A8.–Comparison of age compositions of chinook salmon at Klukshu River weir, as estimated by ADF&G Aging Lab in Juneau and DFO Aging Lab in Nanaimo, 2001.

		Brood year and age class									
		1998	1997	1997	1996	1996	1995	1995	1994	1994	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Males — ADF&G	n	1	49	0	121	0	33	0	1	0	205
	% age	0.5	23.9		59.0		16.1		0.5		46.6
	SE [% age]	0.5	3.0		3.4		2.6		0.5		2.4
— DFO	n	1	22	0	82	5	20	1	0	0	131
	% age	0.8	16.8		62.6	3.8	15.3	0.8	0.0		47.6
	SE [% age]	0.8	3.3		4.2	1.7	3.2	0.8	0.0		3.0
Females—ADF&G	n	0	5	0	192	0	38	0	0	0	235
	% age		2.1		81.7		16.2		0.0		53.4
	SE [% age]		0.9		2.5		2.4		0.0		2.4
— DFO	n	0	5 *a*		111	1	21	3	0	3	144
	% age		3.5		77.1	0.7	14.6	2.1	0.0	2.1	52.4
	SE [% age]		1.5		3.5	0.7	3.0	1.2	0.0	1.2	3.0
Sexes combined —ADF&G	n	1	54	0	313	0	71	0	1	0	440
	% age	0.2	12.3		71.1		16.1		0.2		100.0
	SE [% age]	0.2	1.6		2.2		1.8		0.2		0.0
— DFO	n	1	27	0	193	6	41	4	0	3	275
	% age	0.4	9.8		70.2	2.2	14.9	1.5	0.0	1.1	100.0
	SE [% age]	0.4	1.8		2.8	0.9	2.2	0.7	0.0	0.6	0.0

a: includes 1 age 0.3 fish

Appendix A9.–Computer files used to estimate the spawning abundance and distribution of chinook salmon in the Alsek River, 2001.

File name	Description
Effort01final.XLS	EXCEL spreadsheet with gillnet tagging data--daily effort, catch by species, and water depth by site; gillnet charts.
Alsek01kk.XLS	Age, Sex, Length (ASL) data from tagging site.
Blanchard River chinook. XLS	Age, Sex, Length (ASL) data from spawning ground samples
Ksoutput.doc	KS tests
Kscharts01.XLS	cumulative relative frequency charts and data
Klukshu chinook live age size 2001.XLS	Klukshu weir tags and ASL data

APPENDIX B:

SUMMARY OF 1997 PILOT STUDY TO ESTIMATE CHINOOK SALMON ESCAPEMENT TO ALSEK RIVER

Appendix B: Summary of 1997 pilot study to estimate chinook salmon escapement to Alsek River

In 1997, a pilot study was conducted to determine the feasibility of estimating the escapement of chinook salmon to the Alsek River using a mark-recapture experiment. Set gillnets were fished in the lower Alsek River for 6 hours per day, three days per week for seven weeks between 9 May and 22 June. Each net consisted of 10 fathoms of 5 $^{3/8}$" mesh and 10 fathoms of 7 $^{1/4}$" mesh. A total of 105 chinook and 574 sockeye salmon were captured in 126 net/hours of fishing. Ninety-two large and six medium chinook were tagged and released (Table 1). Two tagged fish were recaptured in the Dry Bay commercial gillnet fishery leaving 96 tagged fish in the study. At the Klukshu River weir 394 chinook salmon were inspected for ASL data and tags, with 4 tags recovered. In the total escapement through the weir of 2,829 fish of all sizes, 17 tags were observed. Length groups can not be estimated in that sample so a mark-recapture estimate was generated for fish of all sizes. With M = 96; C = 2,829; and R = 17, the estimated escapement to the Alsek River is 15,250 fish (SE = 3,147). The weir count represents 19.6% of the total or an expansion factor of 5.1.

Observation of fish passing by the Klukshu weir boosted sample sizes, but did not provide age, size, sex, or tag loss data. The blue tag used in the study was designed to prevent predators from targeting on marked fish. Unfortunately, this same quality hampers recognition at a distance by technicians as well, as reported in subsequent studies. Bearing this in mind, the pilot study indicated that it was feasible to conduct a mark-recapture experiment on chinook salmon returning to the Alsek River, using set gillnets in Dry Bay as the marking site and the Klukshu River weir as the primary recovery site, providing that number of fish inspected at the weir could be increased substantially.

Appendix B1.–Numbers of chinook salmon marked on lower Alsek, removed by fisheries and inspected for marks in tributaries in 1997 by length group.

		Length MEF					
		0–439 mm		440–659 mm		≥660 mm	Total
A. Marked at Dry Bay		0		6		92	98
B. Removed by: U.S. Gillnet		0		0		2	2
Subtotal removals		0	0	0	0	2	2
C. Estimated number of marked fish that survived to spawn		0		6		90	**96**
D. Spawning ground samples							
Observed at: Klukshu Weir	Observed [a]	11		114		2,864	**2,829**
	Marked [b]						**17**
	Marked/unmarked						0.0060
Inspected at:							
1.Klukshu Weir	Inspected	4		20		370	394
	Marked	0		0		4	4
	Marked/unmarked	0.0000		0.0000		0.0108	0.0102
2. Sport fishery	Total catch	1		7		99	107
	Marked						0
	Marked/unmarked						

[a] Sizes estimated from estimated age comp at weir.

[b] Cannot ascertain size.

Appendix B2.–Estimated age composition, by sex, of the estimated escapement of chinook salmon to the Alsek River, 1997.

		Brood year and age class							
		1994	**1993**	**1992**	**1992**	**1991**	**1991**	**1990**	
		1.1	**1.2**	**2.2**	**1.3**	**2.3**	**1.4**	**2.4**	**Total**
Males	n	1	8	0	83	10	34	1	137
	%	0.3	2.5	0.0	25.9	3.1	10.6	0.3	42.8
	SE of %	0.3	0.9	0.0	2.5	1.0	1.7	0.3	2.8
	Escapement	48	381	0	3,955	477	1,620	48	6,529
	SE of esc.	48	152	0	895	176	422	48	1,409
Females	n	0	4	0	127	7	42	3	183
	%	0.0	1.3	0.0	39.7	2.2	13.1	0.9	57.2
	SE of %	0.0	0.6	0.0	2.7	0.8	1.9	0.5	2.8
	Escapement	0	191	0	6,052	334	2,002	143	8,721
	SE of esc.	0	101	0	1,314	140	500	86	1,847
Sexes	n	1	12	0	210	17	76	4	320
combined	%	0.3	3.8	0.0	65.6	5.3	23.8	1.3	100.0
	SE of %	0.3	1.1	0.0	2.7	1.3	2.4	0.6	0.0
	Escapement	48	572	0	10,008	810	3,622	191	15,250
	SE of esc.	48	198	0	2,103	251	828	101	3,147

Appendix B3.–Length composition of chinook salmon sampled at Dry Bay and Klukshu weir, 1997.

		Brood year and age class							
		1994	**1993**	**1992**	**1992**	**1991**	**1991**	**1990**	
		1.1	**1.2**	**2.2**	**1.3**	**1.4**	**2.3**	**2.4**	**Total**
Males	n	1	8	1	83	34	10	1	138
	Avg. length	348	551	610	801	891	867		740
	SD		39	0	90	44	31	0	107
	SE	0	14	0	10	7		0	9
Females	n	0	4	0	127	42	7	3	183
	Avg. length		405		783	862	788	848	764
	SD		125		47	50	35	48	150
	SE		63		4	8	13	27	11
Sexes combined	n	1	12	1	210	76	17	4	321
	Avg. length	348	502	610	790	875	834	636	754
	SD	0	131	0	101	66	47	48	184
	SE	0	38	0	7	8	11	24	10

APPENDIX C:

SUMMARY OF STATISTICAL METHODS

Appendix C1.–Detection of size-selectivity in sampling and its effects on estimation of size composition.

Results of hypothesis tests (K-S and χ^2) on lengths of fish MARKED during the first event and RECAPTURED during the second event	Results of hypothesis tests (K-S) on lengths of fish MARKED during the first event and INSPECTED during the second event
Case I	
"Accept H_o"	"Accept H_o"
There is no size-selectivity during either event	
Case II	
"Accept H_o"	"Reject H_o"
There is no size-selectivity during the second sampling event but there is during the first	
Case III	
"Reject H_o"	"Accept H_o"
There is size-selectivity during both sampling events	
Case IV	
"Reject H_o"	"Reject H_o"
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown	

Case I: Calculate one unstratified abundance estimate and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, sexes, and ages from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second sampling event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Case III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and the analysis can proceed as if there were no size-selective sampling during the second event (Case I or II).

-continued-

Case III or IV: Size-selective sampling in both sampling events

n_i	Number of unique fish sampled during **SECOND** event **ONLY** within stratum *i*
n_{ij}	Number of unique fish of age *j* sampled during the **SECOND** event **ONLY** within stratum *i*
$\hat{p}_{ij} = \dfrac{n_{ij}}{n_i}$	Estimated fraction of fish of age *j* in stratum *i*. Note that $\sum_j \hat{p}_{ij} = 1$
$v(\hat{p}_{ij}) = \dfrac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1}$	An unbiased of variance [1]
$\hat{N}_i$	Estimated abundance in stratum *i* from the mark-recapture experiment
$\hat{N}_j = \sum_i (\hat{p}_{ij}\hat{N}_i)$	Estimated abundance of fish in age group *j* in the population
$v(\hat{N}_j) = \sum_i (v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)\hat{p}^2{}_{ij} - v(\hat{p}_{ij})v(\hat{N}_i))$	An unbiased estimate of variance [2]
$\hat{p}_j = \dfrac{\hat{N}_j}{\sum_i \hat{N}_i} = \dfrac{\hat{N}_j}{\hat{N}}$	Estimated fraction of fish in age group *j* in the population
$v(\hat{p}_j) = \dfrac{\sum_i (v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2)}{\hat{N}^2}$	An approximate estimate of variance [3]

[1] page 52 in Cochran, W.G. 1977. Sampling techniques, 3rd ed. John Wiley and Sons, Inc. New York.

[2] from methods in Goodman, L.G. 1960. On the exact variance of a product. Journal of the American Statistical Association.

[3] from the delta method, page 8 in Seber, G.A.F. 1982. The estimation of animal abundance and related parameters, 2nd ed. Charles Griffin and Company, Limited. London.

Appendix C2.–Procedures used in estimating the abundance of small and medium chinook salmon in the escapement to the Alsek River, 2001.

The estimated number of small chinook salmon $\hat{N}_{sm}$ in the population was calculated as a product of the number of large salmon $\hat{N}_{la}$ estimated through the mark-recapture experiment and an expansion factor $\hat{\theta}$ estimated through sampling to estimate relative size composition of the population:

$$\hat{N}_{sm} = \hat{N}_{la}\hat{\theta}$$

The estimated expansion was calculated as a ratio of two estimated, dependent fractions: $\hat{p}_{sm}$ represents small salmon and $\hat{p}_{la}$ large salmon:

$$\hat{\theta} = \hat{p}_{sm} / \hat{p}_{la}$$

The first step in the calculations to estimate variance involved the variance for the estimated expansion factor. From the delta method (see Seber 1982:7-9):

$$v(\hat{\theta}) \cong \hat{\theta}^2 \left[\frac{v(\hat{p}_{sm})}{\hat{p}_{sm}^2} + \frac{v(\hat{p}_{sm})}{\hat{p}_{la}^2} - \frac{2cov(\hat{p}_{sm},(\hat{p}_{sm})}{\hat{p}_{sm}\hat{p}_{la}} \right]$$

When substituted into the equation above, the following relationships:

$$v(\hat{p}) \cong \frac{\hat{p}(1-\hat{p})}{n} \qquad cov(\hat{p}_{sm}, \hat{p}_{la}) \cong -\frac{\hat{p}_{sm}\hat{p}_{la}}{n}$$

simplify the calculation to:

$$v(\hat{\theta}) \cong \hat{\theta}^2 \left[\frac{1}{n\hat{p}_{sm}} + \frac{1}{n\hat{p}_{la}} \right]$$

where n is the size of the sample taken to estimate relative size of the population.

The final step in the calculations to estimate the variance of $\hat{N}_{sm}$ follows the method of Goodman (1960) for estimating the exact variance of a product:

$$v(\hat{N}_{sm}) = \hat{N}_{la}^2 v(\hat{\theta}) + \hat{\theta}^2 v(\hat{N}_{la}) - v(\hat{\theta})v(\hat{N}_{la})$$

No covariance was involved in the above equation because both variates ($\hat{N}_{sm}$ and $\hat{\theta}$) were derived from independent programs.
